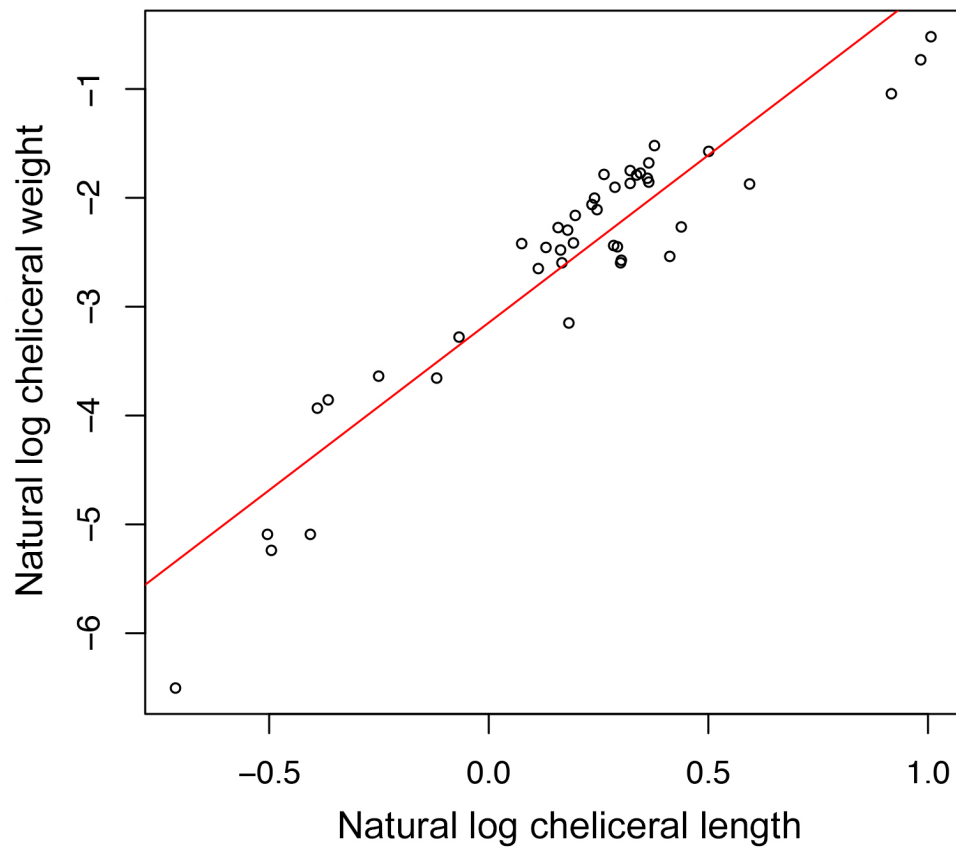


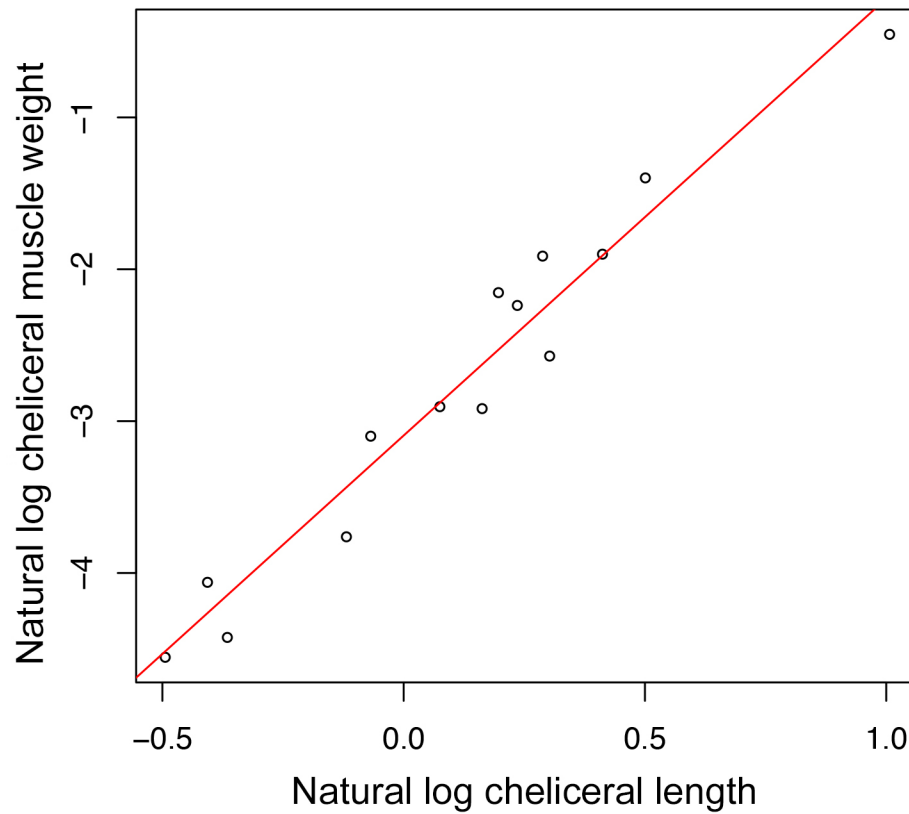
## Supplementary Information

Figure S1



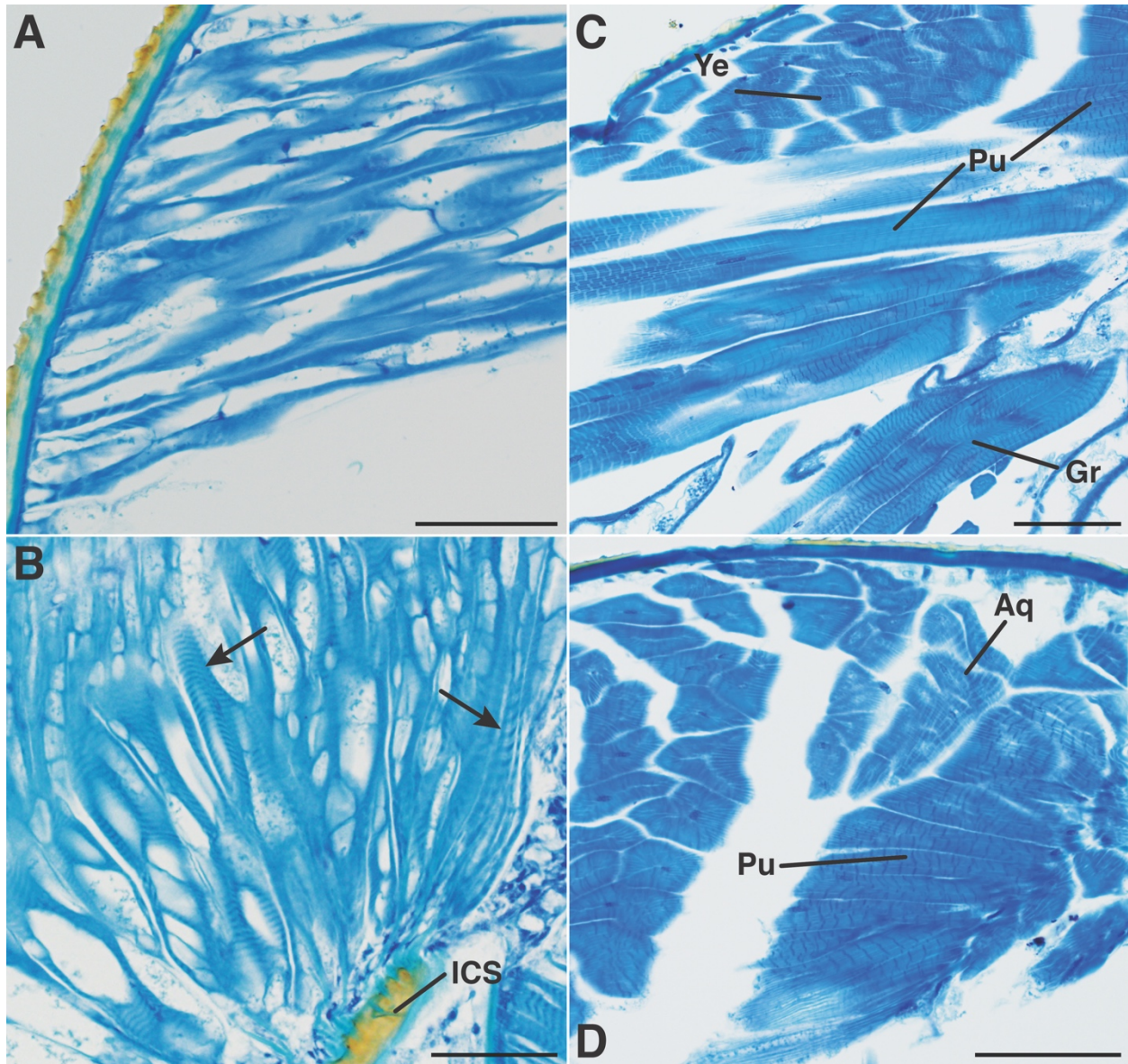
Natural log of cheliceral weight plotted against natural log of cheliceral length. A regression line was fit using the linear model command ('lm') in R (p-value < 0.001). Sample size is 43 specimens.

**Figure S2**



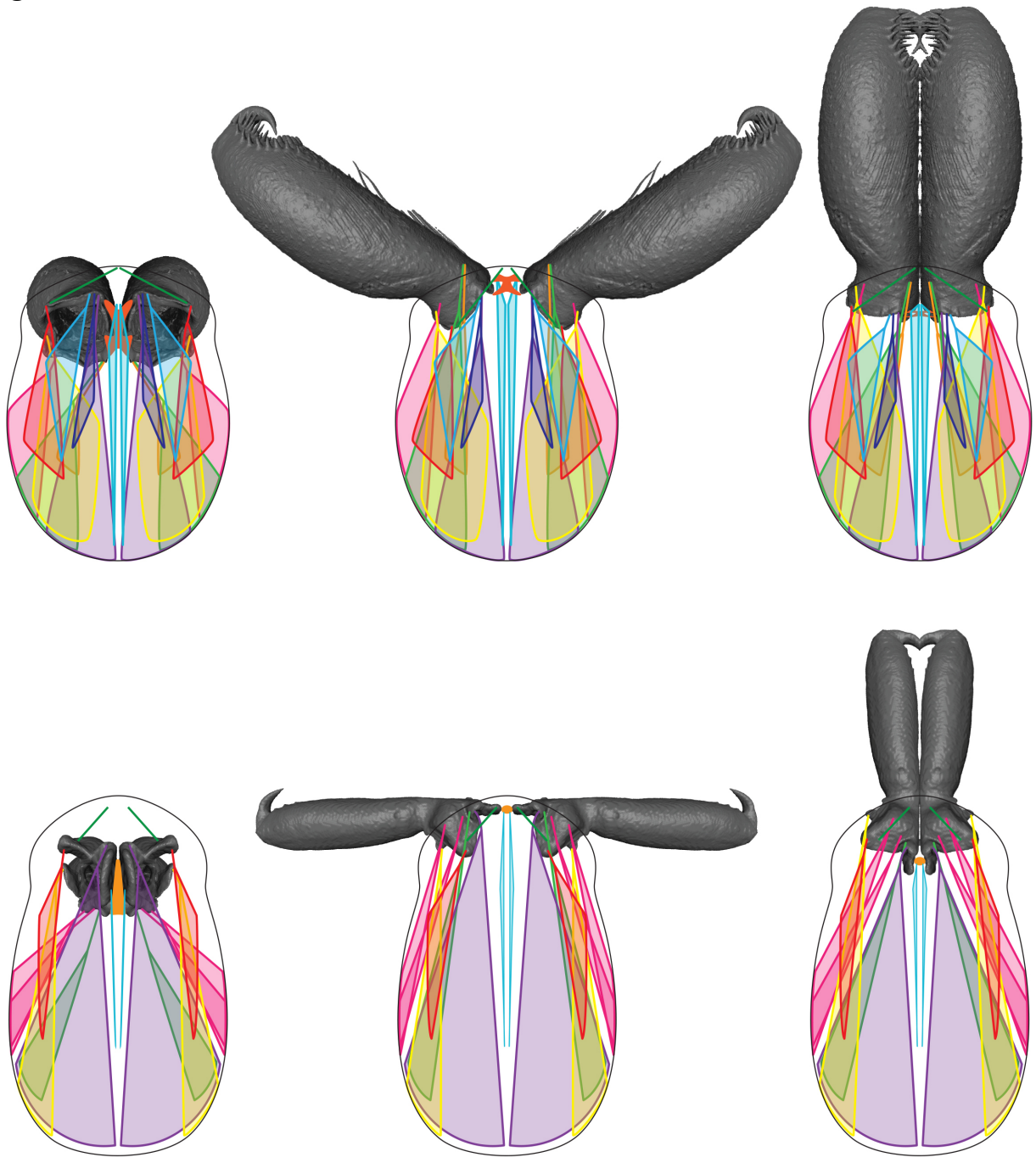
Natural log of cheliceral total muscle mass plotted against natural log of cheliceral length. A regression line was fit using the linear model command (`lm`) in R (p-value < 0.001). Sample size is 14 specimens.

Figure S3



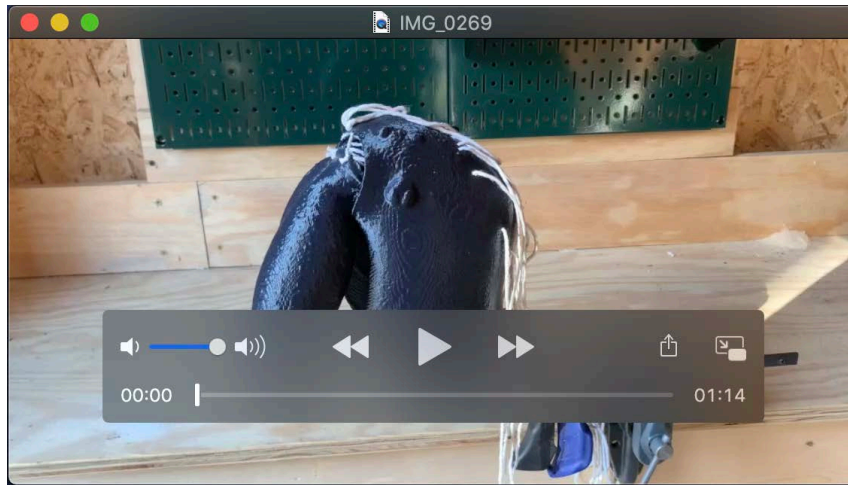
Sarcomere length differences in *Aotearoa magna* (A-B) and *Zearchaea* sp. (C-D). **A.** Anterior medial muscle (color coded purple in Figs. 2 & 4) in *Aotearoa*. **B.** Inter-cheliceral-sclerite muscle (color coded aqua in Figs. 2 & 4) in *Aotearoa*. Arrows show two different fiber types, one with shorter and one with longer sarcomeres; ICS = inter-cheliceral-sclerite. **C.** Different muscles in *Zearchaea*: Ye = lateral anterior muscle (color coded yellow in Figs. 2); Pu = anterior medial muscle (color coded purple in Figs. 2 & 4); Gr = posterior medial muscle (color coded green in Fig. 2). **D.** Different muscles in *Zearchaea*: Aq = inter-cheliceral-sclerite muscle (color coded aqua in Figs. 2 & 4); Pu = anterior medial muscle (color coded purple in Figs. 2 & 4). Scale bars = 50  $\mu$ m.

Figure S4



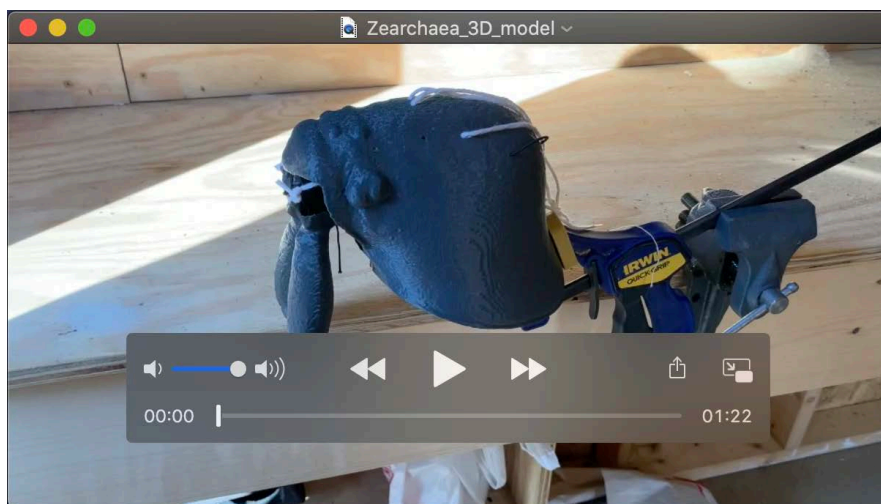
Images of all cheliceral muscles for *Aotearoa* (top) and *Zearchaea* (bottom) in the resting (left), open (middle), and closed (right) positions. The fulcrum occurs where the clypeal ligaments (green) attach to the outer lateral anterior corner of the cheliceral bases. Muscle colors follow Table 1 and Figure 2. Muscles attach to the basal edge of the chelicerae. The chelicerae are opaque dark grey and attachments were drawn on top of the chelicerae even though in many instances the muscles would connect to the posterior edge, beneath the image. For this reason, refer to Figure 2 when interpreting this image.





### Movie 1

Movie showing operation of 3D model in *Aotearoa*.



### Movie 2

Movie showing operation of 3D model in *Zearchaea*.

**Table S1. List of specimens used in study**

Species	Sex, museum voucher number, collection information
<b>High-speed-videography</b>	
<i>Aotearoa magna</i>	Male, museum voucher USNMENT01539031, collection information: NEW ZEALAND: Southland Region, Fiordlands National Park, Cascade Creek, near Lake Gunn outlet, Eglinton Valley, ~64 km NE Te Anau, elev. 500m, S44°53.683' E168°04.918', 13 Mar 2018, sifting moss on tree trunk bases and fallen logs in <i>Nothofagus</i> forest, H. Wood, code: HW0109A
<i>Aotearoa magna</i>	Male, museum voucher USNMENT01539032, collection information: NEW ZEALAND: Southland Region, Fiordlands National Park, Cascade Creek, near Lake Gunn outlet, Eglinton Valley, ~64 km NE Te Anau, elev. 500m, S44°53.683' E168°04.918', 13 Mar 2018, sifting moss on tree trunk bases and fallen logs in <i>Nothofagus</i> forest, H. Wood, code: HW0109A
<i>Zearchaea</i> morphospecies 1	Penultimate female, museum voucher USNMENT01539033, collection information: NEW ZEALAND: West Coast region, Victoria Conservation Park, down Capelston Rd., beginning of Kirwan's Track, S42°04'00.4", E171°55'24.1", elev. 210 m, sifting litter in disturbed <i>Nothofagus</i> forest, Nov 18-19, 2018, H. Wood & T. Nguyen, code: HW0120C
<i>Zearchaea</i> morphospecies 2	Female, museum voucher USNMENT01539030, collection information: NEW ZEALAND: Canterbury Region, close to Lewis Pass, on the southern entrance to St. James Walkway, ~35.8 km W of Hanmer Springs, S42°31'09.7"E172°23'37.4", elev 620m, 18-24 Mar 2011, sifting dense moss on trees, ground, and around logs in daytime in native <i>Nothofagus</i> forest, H. Wood, code: HW0075
<i>Zearchaea</i> morphospecies 2	Female, museum voucher USNMENT01377164, collection information: NEW ZEALAND: Canterbury Region, Lewis Pass, hiked in ~1 km from the northern entrance of St. James Walkway, ~18.7 km E of Springs Junction, S42° 22' 43.0"E172° 24' 06.3", elev 860m, 20-23 Mar 2011, sifting litter and moss on trees, ground, and around logs in daytime in native <i>Nothofagus</i> forest, H. Wood, code: HW0076
<b>Histology specimens</b>	
<i>Aotearoa magna</i>	Male, museum voucher USNMENT01539034, collection information: NEW ZEALAND: Southland Region, Fiordlands National Park, Cascade Creek, near Lake Gunn outlet, Eglinton Valley, ~64 km NE Te Anau, elev. 500m, S44°53.683' E168°04.918', 13 Mar 2018, sifting moss on tree trunk bases and fallen logs in <i>Nothofagus</i> forest, H. Wood, code: HW0109A
<i>Zearchaea</i> morphospecies 3	Female, museum voucher: USNMENT01458827, collection information: NEW ZEALAND: Canterbury Region, near Arthur's Pass, Woolshed Hill track, ~5.5 km N of Cass UC Field Station, elev. 600m - 900m, 18 July 2008, S42°59'12.1" E171°45'12.3", sifting litter and moss on trees, ground, and around logs in daytime, sifting close to stream and higher up in elevation away from stream in <i>Nothofagus</i> forest, H. Wood, code: HW110
<b>μ-Computed tomography scans (Wood &amp; Parkinson, 2019)</b>	
<i>Aotearoa magna</i>	Female, museum voucher CASENT9028269, collection information: NEW ZEALAND: South Island, Fiordland, Gunn's Camp, Feb. 1986, R. Forster
<i>Zearchaea</i> morphospecies 2	Female, museum voucher USNMENT01377164, collection information: NEW ZEALAND: Canterbury Region, Lewis Pass, hiked in ~1 km from the northern entrance of St. James Walkway, ~18.7 km E of Springs Junction, S42° 22' 43.0"E172° 24' 06.3", elev 860m, 20-23 Mar 2011, sifting litter and moss on trees, ground, and around logs in daytime in native <i>Nothofagus</i> forest, H. Wood, code: HW0076

USNMENT, US National Museum, Department of Entomology; CASENT = California Academy of Sciences, Department of Entomology.